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microcomputer to control various tests that are run on blood in order to produce an integrated printout of all test results. *See also* Ada.

embedded servo *See* actuator.

emitter-coupled logic *See* ECL.

empty list (null list) *See* list.

empty medium A *data medium that does not contain variable data but may have a frame of reference or preformatting. *Compare* virgin medium.

empty set (null set; void set) A *set with no elements. It is usually denoted by ϕ.

empty string (null string) A string whose *length is zero. It is commonly denoted by ε or Λ. The possibility of strings being empty is a notorious source of bugs in programs.

emulation The exact execution on a given computer of a program written for a different computer, accepting the identical data and producing the identical results. Emulation is thus the imitation of all or part of one computer system by another system. It is formally defined as being achieved primarily by hardware; it is usually accomplished at the microprogram level. A particular emulation could be used as a replacement for all or part of the system being emulated, and furthermore could be an improved version. For example, a new computer may emulate an obsolete one so that programs written for the old one will run without modification. *See also* simulation, compatibility.

emulator Any system, especially a program or microprogram, that permits the process of *emulation to be carried out.

enable To selectively activate a device or function. When a number of devices are connected in parallel, selective operation can be achieved by an enabling action – such as a signal on a discrete line or a pattern of signals on the common line or lines – that will set only the desired device into a state in which it can receive further signals. *Compare* inhibit.

enable pulse A pulse that must be present to allow other signals to be effective in certain electronic logic circuits. Although the term is now used to describe an electronic logic function it was originally used in an analogous way in connection with *core stores, where the coincidence of two pulses is required to change the state of a core: one of the pulses is the write pulse and can be common to a number of cores; an enable pulse is simultaneously applied to a particular core and thus enables the write pulse to change the state of that core.

encapsulation *See* internetworking.

encoder 1. The means by which an encoding process is effected (*see* code). It may be implemented in hardware or software, the process being algorithmic in nature.

2. A logic circuit, usually an integrated circuit, that generates a unique n-bit binary word, indicating which of its 2^n input lines is active, i.e. at logic 1. A *keyboard encoder*, for example, may be required to generate a unique binary code indicating which key on the keyboard has been pressed.

If two or more of the device inputs can be active simultaneously then a *priority encoder* is required, which usually encodes only the highest-order data input.

encoding 1. The transformation of a message into an encoded form. *See* code.

2. The representation of symbols in some alphabet by symbols or strings of symbols in some other alphabet. A common example is *binary encoding.

encoding format *See* disk format.

character recognition) in which the meaning is assigned after reference to things other than merely the printed shape. Basic OCR systems rely on matching the scanned shape with a set of templates held within a store or on processing the image to extract features, such as lines and loops, and then searching for a match. Both approaches need good-quality printing to achieve usable recognition rates. In desktop publishing applications it is possible to use context to assist the recognition process. The resident dictionary or spelling checker can be used and provision may also be made for the unrecognized shape to be displayed so that the operator can assign a meaning that is then stored for future reference.

idempotent law The law satisfied by any *dyadic operation $\circ$ for which

$$x \circ x = x$$

for all elements x in the domain of $\circ$. *Union and *intersection of sets satisfy these laws. In a *Boolean algebra both of the dyadic operations are idempotent.

identification 1. The process of determining the identity of a user or a using process; it is necessary for *access control. Identification is usually accomplished by *authentication.

2. The process of determining how a control parameter influences a system.

identifier A string of characters used to identify (or *name) some element of a program. The kind of element that may be named depends on the programming language; it may be a variable, a data structure, a procedure, a statement, a higher-level unit, or the program itself.

identity burst *See* tape format.

identity element of a *set S on which some *dyadic operation $\circ$ is defined. An element e with the property that

$$a \circ e = e \circ a = a$$

for all elements a in S. It can be shown that e is unique. In normal arithmetic, 0 and 1 are the identity elements associated with addition and multiplication respectively. In a *Boolean algebra, 0 and 1 are the identities associated with the OR and the AND operations respectively.

identity function A *function

$$I : S \rightarrow S$$

with the property that

$$I(s) = s \text{ for all } s \text{ in } S$$

Such a function leaves every element in its domain unaltered. Identity functions are needed for such purposes as the definition of *inverses of functions.

identity matrix (unit matrix) A *diagonal matrix, symbol I, with each diagonal element equal to one.

idle time *See* available time.

IDP *Abbrev. for* integrated data processing. *See* data processing.

IED *Abbrev. for* Information Engineering Directorate, the UK government department responsible for the program of IT research and development that follows the *Alvey Programme. The programme itself is also called IED.

IEE Institution of Electrical Engineers, a UK organization founded in 1871. It is a qualifying body for professional engineers, a learned society, and a provider of scientific and engineering information services.

IEEE Institute of Electrical and Electronics Engineers, a US organization formed in 1963 by the merger of the IRE (Institute of Radio Engineers) and the AIEE (American Institute of Electrical Engineers).

if and only if statement A well-formed formula of the form

$$A \equiv B$$

where A and B are also appropriate well-formed formulas. *See* biconditional, propositional calculus.

sentinel A *datum that indicates some important state, usually in the context of input or output. For example, an end-of-data sentinel means all the data has been read.

separator A symbol that separates statements in a programming language, e.g. the semicolon in Algol-type languages.

sequence 1. A *function whose domain is the set of positive integers (or sometimes the set of nonnegative integers). The image set can thus be listed $s_1,s_2,$ ... where s_i is the value of the function given argument i. A *finite sequence* (or *list*) is a function whose domain is

$$\{1,2,\ldots,n\} \text{ for } n \geqslant 1$$

and hence whose image set can be listed

$$s_1,s_2,\ldots,s_n$$

2. The listing of the image set of a sequence. Hence it is another name for *string.

sequence control register A part of the *control unit that causes the steps of the fetch and execute processes to occur in the correct sequence/timing.

sequence generator A digital logic circuit whose purpose is to produce a prescribed sequence of outputs. Each output will be one of a number of symbols or of binary or *q-ary *logic levels. The sequence may be of indefinite length or of predetermined fixed length. A binary *counter is a special type of sequence generator. Sequence generators are useful in a wide variety of coding and control applications.

sequencer A logic circuit that produces outputs that are intended to provide coordination stimuli for other logic circuits. The exact timing and sequence of these control outputs is dependent on the sequencer circuitry and may depend on a set of input control signals provided by external devices.

sequencing 1. The procedure by which ordered units of data (octets or messages) are numbered, transmitted over a communications network (which may rearrange their order), and reassembled into the original order at their destination.

2. Proceeding through a program in its ordinary order, normally from sequential memory locations. *See also* loop.

sequency The number of positive-going zero crossings (and therefore half the total number of zero crossings) that the amplitude of a *signal makes per unit time, or, in the case of a spatial signal (a picture), per unit of distance. The term is used mainly with regard to signals capable of taking only one positive and one negative value of amplitude, especially the simple case of +1 unit and −1 unit. Although the amplitude is usually discrete, the time (or space) coordinate may be regarded as discrete or continuous, depending on the application and the mathematical methods to be employed.

The term was originally applied to *Walsh functions. In the case of Walsh functions, or any similar functions which are periodic but in which there are several zero crossings per period at unequal intervals, the number of zero crossings per period is called the *normalized sequency*.

Many concepts such as *bandwidth, and processes such as *filtering, which were originally defined in terms of *frequency, can equally well be defined in terms of sequency. The sequency formulation is often handled more simply and more rapidly by discrete devices such as computers.

See also discrete and continuous systems.

sequential (serial) Involving the occurrence of two or more events or activities such that one must finish before the next begins. If one event or activity immediately follows another then they are said to be *consecutive*.

sequential access A method of access to a *file (especially a data file) or a *database: a file or database is said to be sequentially accessed if the sequence of transactions presented to it matches a sequence in which *records are organized.

sequential algorithm In general, any algorithm executed sequentially, but, specifically, one for decoding a *convolutional code.

sequential circuit (sequential machine) A *logic circuit whose outputs at a specified time are a function of the inputs at that time, and also at a finite number of preceding times. In practice, any physically realizable sequential circuit will have a finite transit time, or delay, between the inputs changing and the outputs changing (one or more of these inputs may be clock signals); the intention of the term sequential is to include not only *combinational circuits but also (explicitly) *memory elements such as flip-flops. Analysis and synthesis of sequential circuits is facilitated by *state diagrams.

sequential cohesion *See* cohesion.

sequential file A file organized to support *sequential access.

sequential function Let I and O be alphabets. A function f from I^* to O^* (*see* word) is sequential if it is the response function of a *sequential machine. Often, though not always, there is the implication that the machine has finitely many states. In this sense therefore sequential function is to function as *regular language is to language, since the regular languages are those recognized by finite-state automata.

sequential machine 1. A *finite-state automaton with output (in some contexts including machines with infinite state-set). Thus there is a function f from the *Cartesian product $I \times Q$ to the product $Q \times O$, with Q a set of states and I, O finite sets of input and output symbols respectively. Suppose, for example,

$$a,q_0 \mapsto q_1,x$$
$$b,q_1 \mapsto q_1,y$$
$$c,q_1 \mapsto q_2,z$$

Then, if the machine is in state q_0 and reads a, it moves to state q_1 and outputs x, and so on. Assuming the starting state to be q_0, it can be seen for example that the input string *abbbc* is mapped to the output string *xyyyz*. This mapping from the set of all input strings to the set of all output strings, i.e. I^* to O^*, is called the *response function* of the machine. The function f comprises a *state-transition function* f_Q from $I \times Q$ to Q and an *output function* f_O from $I \times Q$ to O.

What is described here is sometimes called a *Mealy machine* to distinguish it from the more restricted *Moore machines*. In a Moore machine, the symbol output at each stage depends only on the current state, and not on the input symbol read. The example above is therefore not a Moore machine since

$$f_O(b,q_1) = y$$

whereas

$$f_O(c,q_1) = z$$

Any Moore machine can be converted to an equivalent Mealy machine by adding more states.

A *generalized sequential machine* is an extension of the notion of sequential machine: a string of symbols is output at each stage rather than a single symbol. Thus there is a function from $I \times Q$ to $Q \times O^*$. *See also* gsm mapping.

2. *Another name for* sequential circuit.

sequential search algorithm The most simple searching algorithm in which the keys are searched sequentially from the top of the file until a match is found.

sequential transducer A nondeterministic version of a generalized *sequential machine.